1064506

PATENT SPECIFICATION

DRAWINGS ATTACHED

1064506

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Int. Cl.:—F 25 h // G 21 c

COMPLETE SPECIFICATION

Improvements relating to Tubular Heat Exchange Elements

We, BABCOCK & WILCOX LIMITED, a British Company, of Babcock House, 209—225 Euston Road, London, N.W.1., England, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to tubular heat exchange elements provided with fins, which may extend longitudinally or radially of the element or may spiral along the element.

According to the present invention, there is provided a tubular heat exchanger element having an external fin tapering from the root to the tip and formed with an undulating surface, the depth, transverse of the fin, of the undulations increasing with the distance from the tube. Such tubular elements may be utilised, for example, in connection with the tube bank of a heat exchanger, a tube wall or cans of nuclear fuel elements.

The invention will now be described, by way of example, with reference to the accompanying, partly diagrammatic, drawings, in which:—

Figure 1 is a perspective elevation of a portion of a tube provided with diametrically opposed fins having undulations formed thereon;

Figure 2 is a series of sectional plan views of one of the fins taken on the lines A—A, B—B and C—C of Figure 1;

Figure 3 is a perspective elevation of a portion of an alternative form of tube provided with but a single fin;

Figure 4 is a perspective elevation of a portion of an alternative form of tube provided with a single fin;

Figure 5 is a perspective elevation of a portion of yet a further alternative arrangement of a tube provided with a single fin;

Figure 6 is a perspective elevation of a portion of a tube bank including tubes of the form depicted in Figures 1 and 2;

Figure 7 is a perspective elevation of a portion of a tube wall including tubes of the form shown in Figures 1 and 2; and

Figure 8 is a perspective elevation of a portion of an alternative form of the tube wall shown in Figure 7.

Referring to Figures 1 and 2, there is shown a tube 1 provided with diametrically opposed, longitudinally extending fins 2 each tapering from a root portion 4 to a tip 3 thereof. Undulations 5 are formed on each fin 2 increasing in depth with distance from the tube 1. Thus, the undulations 5 vary from a maximum amplitude at the tip 3 of each fine to zero amplitude at the root portion 4.

In operation, heat is transferred between a fluid flowing within, or a material positioned within, the tube 1 and fluid flowing externally of the tube. The arrangement of the undulations on the tapering fins improves the heat transfer between the tube and the fluid flowing over the tube without incurring a large loss of head in the fluid flowing over the tube due to frictional flow losses normally associated with an arrangement in which a tube is provided with fins formed from corrugated strip of constant thickness and constant depth of corrugation.

The transmission of heat between the tube and fluid flowing over the tube is enhanced lation to the undulations in other fin across the tube.

The finned tube may be manufactured in a variety of ways. Thus, for example, the finned tube may be formed by a drawing and/or forging process or by an extrusion process or by a combined drawing and rolling process, the rolls being provided with external teeth to form the undulations and operating in conjunction with the drawing piston. Alternatively, the undulations may be formed in the fins by a milling process.

In some instances, sufficient transfer of heat between a tube and fluid flowing around the tube may be obtained by providing but a single fin having a tapered undulating form as is

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shown in Figures 3, 4 and 5. Referring to Figure 3, a tube 6 having an otherwise plain surface is provided with a single, tapered fin 7 formed with undulations increasing in depth with distance from the tube similar to the fins described in connection with Figures 1 and 2. A portion 8 of the wall of the tube 6 diametrically opposed to the fin 7 is of greater thickness than the wall adjacent the root of the fin thereby strengthening the tube and facilitating its production by a drawing process. Referring to Figure 4, a tube 9 having an external surface formed with a multiplicity of shallow, longitudinally extending, grooves 10 to enhance heat transfer is provided with a tapering fin 11 having undulations which increase in depth with distance from the tube similar to the fin described in conjunction with Figures 1 and 2. A minor protuberance 12 is formed on the tube diametrically opposite to the tapered fin 10 which serves to strengthen the tube and facilitate the production thereof by a drawing process. Referring to Figure 5, a tube 13 is provided with an external surface having a multiplicity of grooves 17 of a zigzag form extending radially round the tube to enhance heat transfer. The tube 13 is provided with a tapering fin 14 having undulations 15 extending at an oblique angle to the axis of the tube and increasing in depth with distance from the tube, such that the undulations vary in amplitude from a maximum at the tip of the fin to zero at the root of the fin. The portion of the wall of the tube 13 diametrically opposite to the tapered fin 14 is of increased thickness compared with the wall adjacent the root of the fin and is provided with a protuberance 16 to strengthen the tube and to facilitate production of the tube by a drawing process.

Referring to Figure 6, a tube bank 18 includes triangular pitched tubes 19 having diametrically opposed, longitudinally extending, tapering fins 20 arranged with the fins in alignment. The tapering fins 20 are formed with undulations which increase in depth with distance from the tube similar to those described in conjunction with Figures 1 and 2. The undulations in adjacent pairs of fins are arranged in register. Thus the fins define channels between the tubes having undulating boundaries for the flow of fluid over the tubes.

Whilst the foregoing description relates to tubes formed with longitudinally extending fins, it will be appreciated that tubes having radially extending fins and tubes having fins spiralling therearound may also be formed such that the fins taper from root to tip and are provided with undulations having a depth increasing with distance from the tube. Tubes having such an arrangement of fins may be utilized in tube banks of heat exchangers.

In addition it will be appreciated that the various forms of fin hereinbefore described may be formed on the sheaths of nuclear fuel elements to facilitate the transfer of heat from the fuel element to fluid flowing over the element.

The finned tubes may be connected together to form a tube wall, thus, referring to Figure 7, tubes 21 provided with longitudinally extending tapered fins 22 having undulations which increase in depth with distance from the tube similar to those described in conjunction with Figures 1 and 2 are connected together with the fins in alignment and the undulations in register and the tips of adjacent fins 22 connected together by a weld 23. In addition to enhancing the heat transfer properties of the wall, the undulations in the fins also serve to increase the rigidity of the wall. In the alternative arrangement shown in Figure 8, corrugated strips 24 are positioned intermediate the pairs of fins 22 with the corrugations in register with the undulations in the fins and connected to the tips of the fins by welds 26. The corrugated form of the plate 24 readily permits differential thermal expansion between the plate and the tubes 21.

It will be appreciated that the undulations may be formed in only one surface of a fin which tapers from root to tip but which nevertheless is of a thickness at the tip thereof sufficient to accommodate the maximum depth of the undulation. With a greater thickness at the tip of a fin, the undulations may be formed in register on both surfaces of the fin, so that the tip will have an alternatively convergent-divergent edgewise configuration. Normally, however, the undulations alternate on the two surfaces of the fin so that the crest of an undulation on one surface corresponds to the trough of an undulation on the other surface and the tip has a sinusoidal edgewise configuration.

WHAT WE CLAIM IS:—

1. A tubular heat exchange element having an external fin tapering from root to tip and formed with an undulating surface, the depth, transverse of the fin, of the undulations increasing with the distance from the tube.

2. A tubular element as claimed in Claim 1, wherein the fin is formed with undulations on both surfaces.

3. A tubular element as claimed in Claim 2, wherein the crests of undulations on one surface correspond to the trough of the undulations on the other surface.

4. A tubular element as claimed in any preceding claim, wherein the crests and the troughs of the undulations extend perpendicularly to the axis of the tubular element.

5. A tubular element as claimed in any preceding claim, wherein the tubular element is formed with a single fin and the portion of the wall of the tubular element directly opposite the fin is of greater thickness than the portions of the wall of the tubular element immediately adjacent the fin.

6. A tubular element as claimed in Claim

5, wherein the wall of the tubular element directly opposite the fin is formed with a slight outward protuberance.

7. A tubular heat exchange element substantially as hereinbefore described with reference to Figures 1 and 2, or with reference to Figures 3, 4 or 5 of the accompanying drawings.

8. A heat exchanger including tubular heat exchange elements as claimed in any preceding claim.

9. A tube wall including tubular heat exchange elements as claimed in any one of Claims 1 to 4, formed with diametrically opposed fins, with adjacent fins of adjacent tube elements connected together.

10. A tube wall as claimed in Claim 9, wherein a corrugated strip is connected intermediate adjacent pairs of fins in alignment therewith.

11. A tube wall arranged and constructed substantially as hereinbefore described with reference to Figure 7 or Figure 8 of the accompanying drawings.

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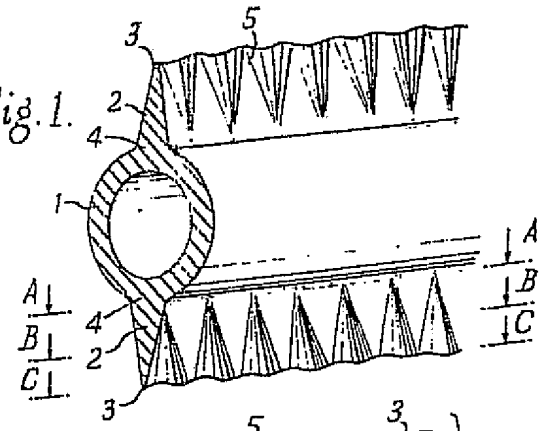
Fig.1.



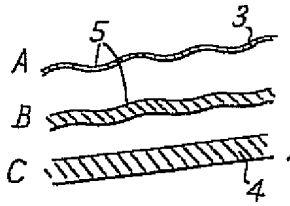


Fig.2.

Fig.3.

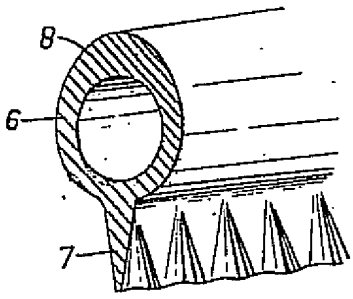


Fig.4.

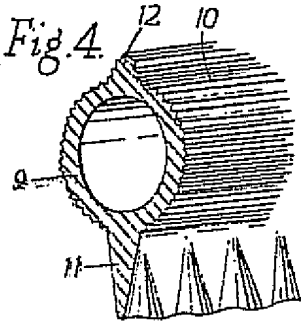
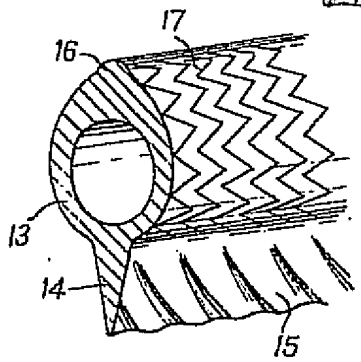


Fig.5.



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Sheets 1 & 2

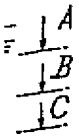


Fig. 2.

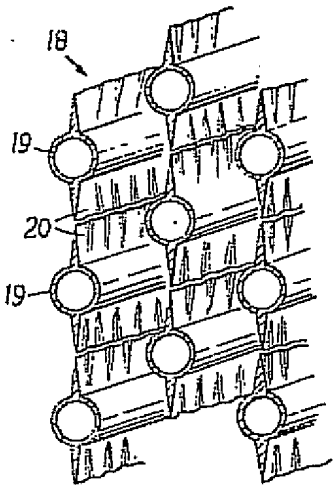
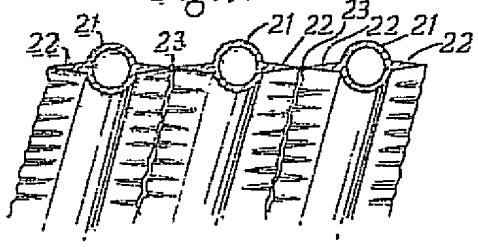


Fig. 6.

Fig. 7.



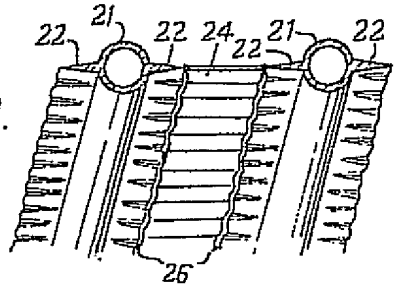


Fig. 8.

1064506 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
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Fig.1.

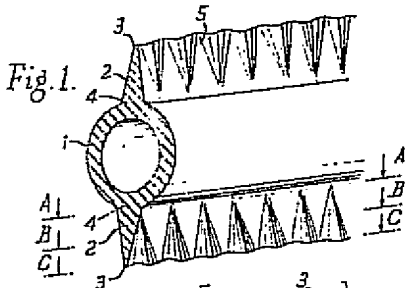

Fig.2.

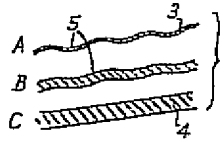

Fig.3.

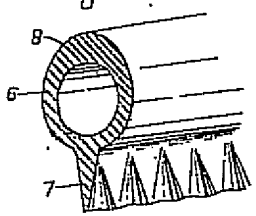

Fig.4.

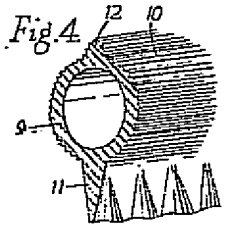

Fig.5.

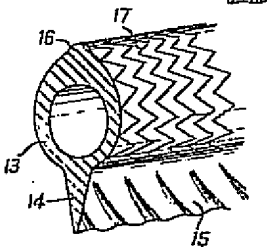

Fig.6.

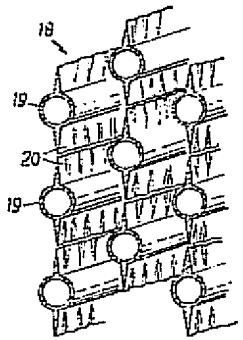

Fig.7.

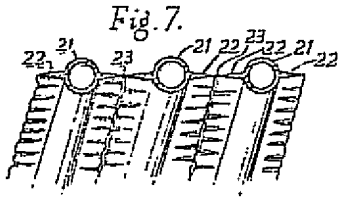

Fig.8.